UNIT 1 Review

Knowledge/Understanding

Multiple Choice

In your notebook, choose the most correct answer for each of the following questions. Outline your reasons for your choice.

1. A ball is thrown upward. After it is released, its acceleration
   - **(a)** is zero
   - **(b)** increases
   - **(c)** decreases
   - **(d)** remains constant
   - **(e)** increases, then decreases
2. You drop a 1.0 kg stone off the roof of a 10-storey building. Just as the stone passes the fifth floor, your friend drops a 1.0 kg ball out of a fifth-floor window. If air resistance is neglected, which of the following statements is true? Explain your reasoning.
   - **(a)** The stone and the ball hit the ground at the same time and at the same speed.
   - **(b)** The stone hits the ground first and with a greater speed than the ball does.
   - **(c)** The stone and the ball hit the ground at the same time, but the speed of the stone is greater.
   - **(d)** The ball hits the ground before the stone.
3. A football is thrown by a quarterback to a receiver deep in the end zone. The acceleration of the football during the flight
   - **(a)** depends on how the ball was thrown
   - **(b)** depends on whether the ball is going up or coming down
   - **(c)** is the same during the entire flight
   - **(d)** is greatest at the top of its trajectory
   - **(e)** is greatest at the beginning and end of its trajectory
4. A ball of mass m_1 is dropped from the roof of a 10-storey building. At the same instant, another ball of mass m_2 is dropped out of a ninth-storey window, 10 m below the roof. The distance between the balls during the flight
   - **(a)** remains at 10 m throughout
   - **(b)** decreases
   - **(c)** increases
   - **(d)** depends on the ratio m_1/m_2
5. On a position-time graph, a straight horizontal line corresponds to motion at
   - **(a)** zero speed
   - **(b)** constant speed
   - **(c)** increasing speed
   - **(d)** decreasing speed

Short Answer

6. **(a)** Define what is meant by a *net* or *unbalanced force* acting on an object.
   - **(b)** Explain, with the aid of a free-body diagram, how an object can be experiencing no net force when it has at least three forces acting on it.
   - **(c)** Describe, with the aid of a free-body diagram, an object that is experiencing a net force. Identify in which direction the object will move and with what type of motion. Relate the direction and type of motion to the direction of the net force.
7. A child is riding a merry-go-round that is travelling at a constant speed.
   - **(a)** Is he viewing the world from an inertial or non-inertial frame of reference? Explain your reasoning.
   - **(b)** What type of force does his horse exert on him to keep him travelling in a circle? In which direction does this force act?
   - **(c)** In what direction does the child feel that a force is pushing him? Explain why this perceived force is called a "fictitious force."
8. A football is kicked into the air. Where in its trajectory is the velocity at a minimum? Where is it at a maximum?
9. A bright orange ball is dropped from a hot-air balloon that is travelling with a constant velocity.
   - **(a)** Draw a sketch of the path the ball will travel from the perspective of a person standing on the ground from the instant in time at which the ball was dropped until the instant it lands.
   - **(b)** From the ground, what type of motion is observed in the horizontal dimension? Identify the mathematical equations that can be used to model this motion.

(c) From the ground, what type of motion is observed in the vertical dimension? Identify the mathematical equations that can be used to model this motion.

(d) Identify the variable that is common to the equations that describe the horizontal motion and those that describe the vertical motion.

(e) Describe, with the aid of sketches, how motion on a plane can be modelled by considering its component motion along two directions that are perpendicular to each other.

Inquiry

10. A rope and pulley are often used to assist in lifting heavy loads. Demonstrate with the use of free-body diagrams and equations that, using the same force, a heavier load can be lifted with a rope and pulley system than with a rope alone.

11. A wooden T-bar attached to a cable is used at many ski hills to tow skiers and snowboarders up the hill in pairs. Design a T-bar lift for a ski hill. Estimate how much tension the cable for an individual T-bar should be able to withstand, assuming that it transports two adults, the slope is 10.0˚, and the T-bar cable pulls the people at an angle of 25.0˚ to the slope. Determine how the tension is affected when the steepness of the slope, the angle of the T-bar cable to the slope, or the coefficient of friction of the snow changes.

12. Examine three different ways of suspending signs (for example, for stores) in front of buildings or above sidewalks by using cables or rods (that is, the sign is not attached directly to the building). Determine which method can support the heaviest sign.

13. Review the meaning of the kinematics equations for constant acceleration by deriving them for yourself. Begin with the following situation. In a time interval, Δt, a car accelerates uniformly from an initial velocity, v_{i}, to a final velocity, v_{f}. Sketch the situation in a velocity-versus-time graph. By determining the slope of the graph and the area under the graph (Hint: What quantities do these represent?), see how many of the kinematics equations you can derive.

Communication

14. According to Newton's third law, for every action force, there is an equal and opposite reaction force. How, then, can a team win a tug-of-war contest?

15. Consider a block of wood on an incline. Determine the acceleration of the block and the normal force of the incline on the block for the two extreme cases where $\theta = 0^\circ$ and $\theta = 90^\circ$, and for the general case of $0^\circ < \theta < 90^\circ$. Discuss the results, particularly why an inclined plane could be described as a way of "diluting" gravity. (**Note:** Galileo recognized this.)

16. You probably have a working understanding of mass and velocity, but what about force and acceleration? At what rate can a person accelerate on a bicycle? What average force does a tennis racquet exert on a tennis ball?

(a) Construct examples of everyday situations involving accelerations of approximately 0.5 $\mathrm{m/s^2}$, 2.0 $\mathrm{m/s^2}$, 5.0 $\mathrm{m/s^2}$, and 20 $\mathrm{m/s^2}$.

(b) Construct examples of everyday situations involving forces of 1 N, 10 N, 50 N, 100 N, 1000 N, and 1.0×10^4 N.

17. A ball rolls down an inclined plane, across a horizontal surface, and then up another inclined plane. Assume there is no friction.

(a) What forces act on the ball at the beginning, middle, and end of its roll?

(b) If the angles of the inclined planes are equal and the ball begins its roll from a vertical height of 10 cm, how high will the ball roll up the second inclined plane?

(c) If the first inclined plane is twice as steep as the second and the ball begins its roll from a vertical height of 10 cm, to what height will the ball roll up the second inclined plane?

(d) If the ball begins its roll from a vertical height of 10 cm on the first inclined plane and the second inclined plane is removed, how far will the ball roll across the horizontal surface?

(e) Explain how the above four situations are explained by using the law of inertia.

18. A car turns left off the highway onto a curved exit ramp.
   (a) What type of motion does the passengers' frame of reference experience relative to the ground?
   (b) Explain why the passengers feel a force to the right as the car turns.
   (c) How would an observer on an overpass describe the motion of the passengers and the car at the beginning of the curve?
   (d) Suppose that in the middle of the turn, the car hits a patch of ice. Sketch the path of the car as it slides.
   (e) Determine the magnitude and direction of the force that the road exerts in dry and icy road conditions and discuss the results for the two situations.

19. Suppose you could place a satellite above Earth's atmosphere with a gigantic crane. In which direction would the satellite travel when the crane released it? Explain your answer.

20. Explain why the kinematics equations, which describe the motion of an object that has constant acceleration, cannot be applied to uniform circular motion.

Making Connections

21. Choose an Olympic sport and estimate the magnitude of realistic accelerations and forces involved in the motion. For example, approximately how fast do Olympic athletes accelerate during the first 10 m of the 100 m dash? What average force is applied during this time? What average force do shot-putters exert on the shot-put as they propel it? How does this compare to the force exerted by discus throwers?

22. In automobiles, antilock braking systems were developed to slow down a car without letting the wheels skid and thus reduce the stopping distance, as compared to a braking system in which the wheels lock and skid. Explain the physics behind this technology, using the concepts of static friction and kinetic friction. Develop and solve a problem that demonstrates this situation. In which case, stopping without skidding or stopping with skidding, do you use the coefficient of kinetic friction and in which case do you use the coefficient of static friction?

23. "Natural motion" is difficult to explore experimentally on Earth because of the inherent presence of friction. Research the history of friction experiments. Examine the relationship between static and kinetic friction. Explain why a fundamental theory of friction eludes physicists.

24. Aristotle's theory of dynamics differed from Newton's and Galileo's theories partly because Aristotle tried to develop common sense explanations for real-life situations, whereas Newton and Galileo imagined ideal situations and tested them by experiment. Outline in an essay the differences in these two approaches and their results.

25. Railroads are typically built on level land, but in mountainous regions, inclines are unavoidable. In 1909, to improve the Canadian Pacific Railway through the Rocky Mountains, near Field, British Columbia, engineers significantly reduced the grade of the old track by building a spiral tunnel through a mountain. Research this engineering feat and answer the following questions.
   (a) What is the grade of the incline?
   (b) How much force must the train exert going up through the tunnel, as compared to when it goes down or travels on level track, or as compared to what it required for travel on the old track?
   (c) What is the elevation of the train before entering and after leaving the tunnel?
   (d) What is the typical acceleration of the train in the tunnel? Make some rough calculations, if necessary, to support your answers.

26. Tycho Brahe built two observatories and had his assistants observe the same things independently. He also repeated observations in order to understand his errors. He is recognized as the greatest astronomical observer prior to development of the telescope. Research the

contribution he made to observational astronomy and the role his methods played in developing the scientific method.

27. In the solar system, objects at greater distances from the Sun have slower orbital velocities because of the decrease in the gravitational force from the Sun. This pattern is expected to be observed in the Milky Way galaxy also. However, some objects that are more distant from the centre of the galaxy than the Sun (such as star clusters) have higher orbital velocities than the Sun. This is considered to be evidence for dark matter in the galaxy. Review some recent articles in astronomy magazines and research the nature of this problem. Why are the above observations considered to be evidence for dark matter? How strong is this evidence? What are some of the candidates?

28. Volcanoes on Mars, such as Olympus Mons, are much taller than those on Earth. Compare the sizes of volcanoes on different bodies in the solar system and discuss the role that gravity plays in determining the size of volcanoes.

Problems for Understanding

29. A 1.2×10^3 kg car is pulled along level ground by a tow rope. The tow rope will break if the tension exceeds 1.7×10^3 N. What is the largest acceleration the rope can give to the car? Assume that there is no friction.

30. Two objects, m_1 and m_2, are accelerated independently by forces of equal magnitude. Object m_1 accelerates at 10.0 m/s^2 and m_2 at 20.0 m/s^2. What is the ratio of **(a)** their inertial masses? **(b)** their gravitational masses?

31. A 720 kg rocket is to be launched vertically from the surface of Earth. What force is needed to give the rocket an initial upward acceleration of 12 m/s^2? Explain what happens to the acceleration of the rocket during the first few minutes after lift-off if the force propelling it remains constant.

32. A 42.0 kg girl jumps on a trampoline. After stretching to its bottom limit, the trampoline exerts an average upward force on the girl over a displacement of 0.50 m. During the time that the trampoline is pushing her up, she experiences an average acceleration of 65.0 m/s^2. Her velocity at the moment that she leaves the trampoline is 9.4 m/s[up].
- **(a)** What is the average force that the trampoline exerts on the girl?
- **(b)** How high does she bounce?

33. An 8.0 g bullet moving at 350 m/s penetrates a wood beam to a distance of 4.5 cm before coming to rest. Determine the magnitude of the average force that the bullet exerts on the beam.

34. Soon after blast-off, the acceleration of the *Saturn V* rocket is 80.0 m/s^2[up].
- **(a)** What is the apparent weight of a 78.0 kg astronaut during this time?
- **(b)** What is the ratio of the astronaut's apparent weight to true weight?

35. A 1500 kg car stands at rest on a hill that has an incline of 15°. If the brakes are suddenly released, describe the dynamics of the car's motion by calculating the following: **(a)** the car's weight, **(b)** the component of the weight parallel to the incline, **(c)** the car's acceleration, **(d)** the velocity acquired after travelling 100.0 m (in m/s and km/h), and **(e)** the time for the car to travel 100.0 m.

36. A 2.5 kg brick is placed on an adjustable inclined plane. If the coefficient of static friction between the brick and the plane is 0.30, calculate the maximum angle to which the plane can be raised before the brick begins to slip.

37. Superman tries to stop a speeding truck before it crashes through a store window. He stands in front of it and extends his arm to stop it. If the force he exerts is limited only by the frictional force between his feet and the ground, and $\mu_s = \mu_k = 1.0$, **(a)** what is the maximum force he can exert? (Let Superman's mass be 1.00×10^2 kg, the truck's mass 4.0×10^4 kg, and the truck's velocity 25 m/s.) **(b)** What is the minimum distance over which he can stop the truck?

38. Two bricks, with masses 1.75 kg and 3.5 kg, are suspended from a string on either side of a pulley. Calculate the acceleration of the masses and the tension in the string when the masses are released. Assume that the pulley is massless and frictionless.

39. A helicopter is flying horizontally at 8.0 m/s when it drops a package.
- **(a)** How much time elapses before the velocity of the package doubles?
- **(b)** How much additional time is required for the velocity of the package to double again?
- **(c)** At what altitude is the helicopter flying if the package strikes the ground just as its velocity doubles the second time?

40. A soccer player redirects a pass, hitting the ball toward the goal 21.0 m in front of him. The ball takes off with an initial velocity of 22.0 m/s at an angle of 17.0° above the ground.
- **(a)** With what velocity does the goalie catch the ball in front of the goal line?
- **(b)** At what height does the goalie catch the ball?
- **(c)** Is the ball on its way up or down when it is caught?

41. A wheelchair basketball player made a basket by shooting the ball at an angle of 62°, with an initial velocity of 6.87 m/s. The ball was 1.25 m above the floor when the player released it and the basket was 3.05 m above the floor. How far from the basket was the player when making the shot?

42. A 10.0 g arrow is fired horizontally at a target 25 m away. If it is fired from a height of 2.0 m with an initial velocity of 40.0 m/s, at what height should the target be placed above the ground for the arrow to hit it?

43. A Ferris wheel of radius 10.0 m rotates in a vertical circle of 7.0 rev/min. A 45.0 kg girl rides in a car alone. What (vertical) normal force would she experience when she is:
- **(a)** halfway towards the top, on her way up?
- **(b)** at the top?
- **(c)** halfway towards the bottom?
- **(d)** at the bottom?

Compare this to her weight in each case.

44. How much force is needed to push a 75.0 kg trunk at constant velocity across a floor, if the coefficient of friction between the floor and the crate is 0.27?

45. A car can accelerate from rest to 100 km/h (1.00×10^2 km/h) in 6.0 s. If its mass is 1.5×10^3 kg, what is the magnitude and direction of the applied force?

46. A 62.4 kg woman stands on a scale in an elevator. What is the scale reading (in newtons) for the following situations.
- **(a)** The elevator is at rest.
- **(b)** The elevator has a downward acceleration of 2.80 m/s^2.
- **(c)** The elevator has an upward acceleration of 2.80 m/s^2.
- **(d)** The elevator is moving upward with a constant velocity of 2.80 m/s.

47. Suppose you attach a rope to a 5.0 kg brick and lift it straight up. If the rope is capable of holding a 20.0 kg mass at rest, what is the maximum upward acceleration you can give to the brick?

48. A 52.0 kg parachutist is gliding to Earth with a constant velocity of 6.0 m/s[down]. The parachute has a mass of 5.0 kg.
- **(a)** How much does the parachutist weigh?
- **(b)** How much upward force does the air exert on the parachutist and parachute?

49. **(a)** If you want to give an 8.0 g bullet an acceleration of 2.1×10^4 m/s^2, what average net force must be exerted on the bullet as it is propelled through the barrel of the gun?
(b) With this acceleration, how fast will the bullet be travelling after it has moved 2.00 cm from rest?

50. A snowboarder, whose mass including the board is 51 kg, stands on a steep 55° slope and wants to go straight down without turning. What will be his acceleration if **(a)** there is no friction and **(b)** the coefficient of kinetic friction is 0.20? **(c)** In each case, starting from rest, what will be his velocity after 7.5 s?

51. Replace the cart in a Fletcher's trolley apparatus (see page 8) with a block of wood of mass 4.0 kg and use a suspended mass of 2.0 kg. Calculate the acceleration of the system and the tension in the string when the mass is released, if the coefficient of friction between the block of wood and the table is
(a) 0.60
(b) 0.20
(c) What is the maximum value of the coefficient of friction that will allow the system to move?

52. Calculate the acceleration of two different satellites that orbit Earth. One is located at 2.0 Earth radii and the other at 4.0 Earth radii.

53. **(a)** Calculate your velocity on the surface of Earth (at the equator) due to Earth's rotation.
(b) What velocity would you require to orbit Earth at this distance? (Neglect air resistance and obstructions.)

54. Two galaxies are orbiting each other at a separation of 1×10^{11} AU and the orbital period is estimated to be 30 billion years. Use Kepler's third law to find the total mass of the pair of galaxies. Calculate how many times larger the mass of the pair of galaxies is than the Sun's mass, which is 1.99×10^{30} kg.

COURSE CHALLENGE

Scanning Technologies: Today and Tomorrow

Consider the following as you begin gathering information for your end-of-course project.

- Analyze the contents of this unit and begin recording concepts, diagrams, and equations that might be useful.
- Collect information in a variety of ways, including concept organizers, useful Internet sites, experimental data, and perhaps unanswered questions to help you create your final presentation.
- Scan magazines, newspapers, and the Internet for interesting information to enhance your project.